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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. |
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09/092.158 06/05/98 MERCHANT

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| EXAMINER |
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MM12/1228

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| FATON, K | |
| ART UNIT | PAPER NUMBER |

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2823
DATE MAILED:

12/28/99

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

Office Action Summary

Application No.

09/092,158

Applicant(s)

MERCHANT ET AL.

Examiner

Kurt M Eaton

Art Unit

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136 (a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).

Status

- 1) ☒ Responsive to communication(s) filed on 09 June 1999.
- 2a) ☐ This action is FINAL. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-23 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-23 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claims _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☒ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are objected to by the Examiner.
- 11) ☐ The proposed drawing correction filed on _____ is: a) ☐ approved b) ☐ disapproved.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).
- a) ☐ All b) ☐ Some * c) ☐ None of the CERTIFIED copies of the priority documents have been:
1. ☐ received.
2. ☐ received in Application No. (Series Code / Serial Number) _____.
3. ☐ received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- * See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. & 119(e).

Attachment(s)

- 14) ☒ Notice of References Cited (PTO-892)
- 15) ☒ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 16) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 4.

- 17) ☐ Interview Summary (PTO-413) Paper No(s). _____.
- 18) ☐ Notice of Informal Patent Application (PTO-152)
- 19) ☐ Other: _____.

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DETAILED ACTION

Specification

1. The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

The following is a quotation of 37 CFR 1.71(a)-(c):

- (a) The specification must include a written description of the invention or discovery and of the manner and process of making and using the same, and is required to be in such full, clear, concise, and exact terms as to enable any person skilled in the art or science to which the invention or discovery appertains, or with which it is most nearly connected, to make and use the same.
- (b) The specification must set forth the precise invention for which a patent is solicited, in such manner as to distinguish it from other inventions and from what is old. It must describe completely a specific embodiment of the process, machine, manufacture, composition of matter or improvement invented, and must explain the mode of operation or principle whenever applicable. The best mode contemplated by the inventor of carrying out his invention must be set forth.
- (c) In the case of an improvement, the specification must particularly point out the part or parts of the process, machine, manufacture, or composition of matter to which the improvement relates, and the description should be confined to the specific improvement and to such parts as necessarily cooperate with it or as may be necessary to a complete understanding or description of it.

The specification is objected to under 37 CFR 1.71 because the specification does not disclose enabling subject matter which is claimed in claim 23 (i.e., forming said active device includes forming an active device having a design width of about 0.25 microns or less).

2. The title of the invention is not descriptive. A new title is required that is clearly indicative of the invention to which the claims are directed.

Claim Rejections - 35 USC § 112

3. The following is a quotation of the first paragraph of 35 U.S.C. 112:

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The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

4. Claim 23 is rejected under 35 U.S.C. 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention. Subject matter for which the specification is not enabling is included in claim 23 and more specifically the limitation "wherein forming said active device includes forming an active device having a design width of about 0.25 microns or less" is not enabled by the specification.

Claim Rejections - 35 USC § 103

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

6. Claims 1-6, 8-17 and 19-22 are rejected under 35 U.S.C. 103(a) as being unpatentable over applicants admitted prior art in view of Schinella et al. and Chen.

Applicants admitted prior art shows in Figures 1A, 1B, and 2 a process for fabricating an integrated circuit including the steps of: using 0.25 micron technology, forming an active device (120) on a semiconductor substrate; forming a contact opening (110) having an aspect ratio ranging from about 3:1 to about 5:1 in a dielectric (101) deposited on the active device, wherein the contact opening is in electrical contact with the active device; depositing a barrier layer (114 and 116) in the

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contact opening and on at least a portion of the semiconductor substrate, wherein depositing the barrier layer includes depositing a titanium layer (114) by physical vapor deposition and depositing a titanium nitride layer (116) on the titanium layer by physical vapor deposition, and wherein the thickness of the barrier layer within the contact opening ranges from about 3.5 nm to about 30 nm and the thickness of the barrier layer in a field area of the device ranges from about 75 nm to about 150 nm (i.e., wherein the thickness of the barrier layer within the contact opening is about 5% to 20% of the field area thickness of the barrier layer); annealing the barrier layer in an RTP process; chemical vapor depositing a contact metal including tungsten on the barrier layer within the contact opening {page 1, line 9 – page 6, line 21}. The admitted prior art also teaches that the RTP process performed after barrier layer deposition causes the portion of the titanium nitride layer in the field region to crack thereby forming additional nucleation sites for tungsten growth and causing delamination between the titanium and titanium nitride layers {page 6, lines 3-15}.

The admitted prior art does not show depositing the contact metal immediately after deposition of the barrier layer; removing a substantial portion of the contact metal and the barrier layer from the semiconductor substrate and forming a contact plug within the contact opening, wherein removing includes removing the contact metal and the barrier layer from the field area of the substrate by CMP techniques; or subjecting the contact plug to a temperature sufficient to anneal the barrier layer.

Schinella et al. (herein referred to as Schinella) shows, in an analogous art related to semiconductor processing technology and to the use of titanium nitride layers with tungsten plugs in vias to make interlayer connections, in Figures 3A-3E providing a contact hole (54) in a dielectric layer (52); depositing a barrier layer (56 and 58) including a physically vapor deposited titanium layer

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(56) and a titanium nitride layer (58) physically vapor deposited over the titanium layer, wherein there is approximately a 9:1 difference between the thickness of the barrier layer on the upper surface of the dielectric layer as compared to the bottom of the contact hole; chemically vapor depositing a contact metal layer (60) made of tungsten over the barrier layer within the contact opening; and removing, by CMP, a substantial portion of the contact metal and the barrier layer from the semiconductor substrate and forming a contact plug (62) within the contact opening {column 3, line 59 – column 4, line 54; column 5, lines 29-51}.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to deposit the contact metal layer of the admitted prior art immediately after deposition of the barrier layer, and without an intervening RTP process, as in Schinella since the deposition sequence of Schinella produces a contact metallurgy in which the titanium layer does not crack and thus resists delamination. It also would have been obvious to use CMP techniques to remove a substantial portion of the contact metal and the barrier layer of the admitted prior art from the semiconductor substrate, thereby forming a contact plug within the contact opening as in Schinella since formation of a contact plug would have allowed for more subsequent wiring formations to be electrically and selectively contacted to the active devices thereby allowing for the function of the device to be realized.

The admitted prior art in view of Schinella still does not show subjecting the contact plug to a temperature sufficient to anneal the barrier layer.

Chen shows, in an analogous art related to a method of making a semiconductor device, in Figures 2A-2C providing a dielectric layer (13) with a contact hole (15) therein exposing an active device (12); forming a barrier layer (16' and 16) made of a titanium layer (16') and a titanium nitride

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layer (16) formed on the titanium layer; depositing a contact metal (18) made of tungsten on the barrier layer within the contact opening; and subjecting the contact plug to a heat treatment sufficient to transform the titanium layer in the barrier layer to a low resistance titanium silicide layer thereby reducing the overall resistance of the materials within the contact hole {column 2, line 50 – column 3, line 21}.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to subject the contact plug of the admitted prior art to a heat treatment as in Chen since the heat treatment of Chen would have transformed the titanium layer in the barrier layer of the admitted prior art into a lower resistance material, thereby improving the overall performance of the device.

7. Claims 7 and 18 are rejected under 35 U.S.C. 103(a) as being unpatentable over the admitted prior art in view of Schinella and Chen as applied to claims 1 and 12 above, and further in view of Inoue et al..

The admitted prior art in view of its modifiers substantially discloses the invention as claimed but fails to show wherein the heat treatment includes a rapid thermal anneal process which is carried out from about 5 seconds to about 60 seconds at a temperature ranging from about 600 °C to about 750 °C.

Inoue et al. (herein referred to as Inoue) teaches, in an analogous art related to a fabrication process for a semiconductor device, titanium may be transformed into titanium silicide by performing an RTP process at a temperature of 650 °C for a period of 30 seconds {column 6, line 64 – column 7, line 1}.

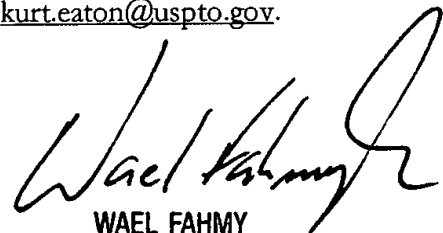
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It would have been obvious to one of ordinary skill in the art at the time the invention was made to heat treat the titanium layer in the barrier layer of the admitted prior art in view of its modifiers as prescribed by Inoue since, as evidenced by Inoue, RTP at 650 °C for 30 seconds to form titanium silicide from titanium and silicon is well known in the art.

Conclusion

8. Paper related to this application may be submitted directly to Art Unit 2823 by facsimile transmission. Papers should be faxed to Art Unit 2823 via the Art Unit 2823 Fax Center located in Crystal Plaza 4, room 4C23. The faxing of such papers must conform with the notice published in the Official Gazette, 1096 OG 30 (15 November 1989). The Art Unit 2823 Fax Center number is (703) 308-7722 or -7724. The Art Unit 2823 Fax Center is to be used only for papers related to Art Unit 2823 applications.

Any inquiry concerning this communication of earlier communication from the examiner should be directed to **Kurt Eaton** at (703) 305-0383 and between the hours of 8:00 AM to 4:00 PM (Eastern Standard Time) Monday through Friday or by e-mail via kurt.eaton@uspto.gov.



Wael Fahmy
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